The NERC MST Radar Facility at Aberystwyth
http://mst.nerc.ac.uk

Minutes of the 44th Experimenters' Meeting
The Cosener's House, Abingdon, Thursday 21st January 2010

Present:

Dr David Hooper[3,4]	(DAH)	Secretary
Mr Dan Housley[5]	(DJH)	
Mr Chris Lee[5]	(CFL)	
Mr Kevin Linklater[2]	(KL)	
Dr Emily Norton[5]	(EGN)	
Mr James Ovens[2]	(JO)	
Dr Graham Parton [1,4]	(GAP)	
Dr Jeremy Price[2]	(JP)	
Mr Hugo Ricketts[5]	(HMAR)	
Prof Geraint Vaughan[5]	(GV)	Chair

[1]British Atmospheric Data Centre (BADC)
[2]Met Office (MO)
[3]NERC MST Radar Facility
[4]Rutherford Appleton Laboratory (RAL)
[5]University of Manchester

Other abbreviations used in this document:

BLWP	Boundary-Layer Wind-Profiler
DPW	Dave Wareing (University of Manchester technician)
ECMWF	European Centre for Medium-Range Weather Forecasts
EU	European Union
FAAM	(NERC/MO) Facility for Airborne Atmospheric Measurements
FGAM	Facility for Ground-based Atmospheric Measurement (formerly UFAM)
FUND	Future Upper-Air Network Development (an MO project)
GPS	Global Positioning System
LD	Les Dean (part-time site technician)
MST(R)(F)	Mesosphere-Stratosphere-Troposphere (Radar) (Facility)
NERC	Natural Environment Research Council
PC	Personal Computer

1. Minutes of the previous meeting

The minutes of the previous meeting were accepted without correction.

2. Matters arising

ACTION ITEM 43.3.1 JN to inform DAH of the days on which the Aberystwyth MST radar failed to measure strong winds and DAH to investigate the cause of this failure.

ONGOING

JN was not at this meeting and so was unable to comment on this action item.

ACTION ITEM 43.4.1 GV to provide DAH, by the time of the 44th meeting, with sample computer code used by members of his (GV's) group to read MSTRF data from netCDF files. DAH to make the sample code available through the Facility's website as soon as possible.

ONGOING

GV has recently written some IDL code to read in data from the MST radar Cartesian data files. He will forward this to DAH.

ACTION ITEM 43.5.1 HMAR to deposit CSIP ozone data on the BADC before the 44th Experimenters' meeting.

COMPLETED

ACTION ITEM 43.6.1 DAH to create a facility for automatically-plotting near-real-time unaveraged MST radar data in time for the July 2009 phase of the turbulence campaign.

COMPLETED

This facility creates both time-altitude plots of the latest 24 hours' worth of data and altitude profiles of the latest 2 hours' worth of data. These are automatically updated every 10 minutes. DAH commented that this facility had proved to be extremely useful for allowing him to quickly identify any problems with radar operation. He had created a similar facility for plotting cloud base data from the laser ceilometer at the beginning of 2009 and hopes to create one for the Vaisala WXT510 surface met data in the near future.

3. Facility Report

DAH reported that he had recently updated the Facility's Risk Assessment and that he would soon distribute copies to all interested parties. Moreover, he had created a 1 page document of instructions on how to find the radar site. He will make this available through the Facility's website as it will be of use to any new visitors to the site.

ACTION ITEM 44.3.1 DAH to distribute, as soon as possible, the updated version of the Facility's Risk Assessment to all interested parties and to make the document which describes the Facility's location publicly available through the website.

NEW

3a) MST Radar renovation

The performance of the MST radar has decreased noticeably over the past decade. The maximum useful altitude for wind-profiling purposes has reduced from nearly 20 km to almost 15 km. Extensive surveys of the entire system have revealed that a severe degradation of the electro-mechanical relay units (which are required for beam steering) is likely to be the primary cause. Consequently the Facility has recently undertaken a European Union (EU) competitive tendering process in order to find a company to supply and to install replacement components. Six companies responded to a notice placed in the Official Journal of the EU in October 2009. All were invited to tender and bids were finally received from four of them. A meeting was held on 13th January 2010 in order to select a winning tender. The contract, paid for by NERC, will be placed shortly and the installation work is anticipated to take place during the latter part of 2010. The radar will be out of operation for an approximately 2 week period whilst this is

undertaken.

A document entitled *"A Detailed Analysis Of The NERC MST Radar At Aberystwyth After Twenty Years Of Operation"* was written during the latter part of 2009 for the benefit of the tendering companies. This contains many technical details which are not recorded in any other official documents. Consequently it is intended that it will be published as a RAL technical document during 2010. Until then, copies can be made available upon request to DAH.

DAH reported that an additional cause for the reduction in radar altitude coverage was the fact that the transmitters have had their output powers deliberately reduced. It is thought that Tony Olewicz, the former site manager, had found them to be more reliable when they were operated at less than their peak powers. However, the fact that they were on their lowest settings did not become apparent until 21st December 2009 when Les Dean (LD) was investigating a failure of the phase locking unit to perform its function correctly. Sub-optimal transmitter output power is thought to have been cause. The radar starting to malfunction on Friday 18th December 2009. LD was unable to establish the cause of the problem during the afternoon and the radar had to be left powered down for the whole of the following weekend. It took until 16:00 UT on the following Monday (21st) before normal operations were resumed. LD has made a number of attempts to increase transmitter powers by changing their output valves. Although this has had little effect on TX1 (9th October 2009), the output power for TX5 on its lowest setting almost doubled (12th January 2010). Efforts to further boost the output powers will be delayed until after the renovation work has been undertaken.

3b) Campaigns involving the MSTRF

Two campaigns involving the MST radar have been conducted over the past 6 months. The third phase of the turbulence campaign was carried out between 29th June and 10th July 2009. Radiosondes were launched from the site on each of the weekdays and an ozonesonde was launched on 8th July. The radar was operated in a special mode (interlacing 150 m and 300 m range resolution observations) from 6th to 13th July. Overflights were made by the NERC Dornier aircraft on 8th and 9th July. The THAW (Temperature Humidity And Water) campaign was conducted between 23rd November and 4th December 2009 - see Section 6a for further details. The same MST radar observation format was used as for the turbulence campaign (these were continued until 7th December). Overflights were made by the FAAM aircraft on 27th and 30th November. The FAAM aircraft additionally made observations of fronts as part of T-NAWDEX (THORPEX - North Atlantic Waveguide and Downstream Interact Experiment) on 3rd, 13th and 24th November 2009. Although the aircraft was a considerable distance away from the radar site, it is intended to use the radar observations to provide additional details about the fronts as they passed overhead several hours later.

GV reported that one of his research grant applications involving the MST radar had just been funded. The project is named *"Trosiad"* - the Welsh word for conversion - and it will investigate the effect of tropopause folds on convection.

3c) MST Radar article for NERC's *"Planet Earth"*

A journalist employed by NERC to make podcasts for its *"Planet Earth"* publication visited the radar site on 10th August 2009. He interviewed GV and DAH about the turbulence campaign. The podcast, which is titled *"Geoengineering, wind and sea squirts"*, was made available shortly after the 44th meeting but before these minutes were completed. It is available from
http://planetearth.nerc.ac.uk/multimedia/story.aspx?id=660. The MST radar part of the podcast fills the first 8 minutes 30 s.

3d) Electricity

There was a lightning strike close to the radar site at some point between 14:00 and 15:00 UT on 1st September 2009. It appears that the mains electricity was briefly lost, although all instruments continued

to operate thanks to the Uninterruptible Power Supply units.

All instruments were powered down between 09:00 and 12:30 UT on 13th November 2009 in order to allow the mains distribution board and circuit breakers to be replaced. Subsequent to the NERC Estates work being carried out during March 2009, it transpired that switching on the along-track lights caused the mains to trip for the whole site. It was thought that the old-style circuit breakers, which trip for a lower leakage current compared to their modern counterparts, were to blame. In fact, the new circuit breakers have not solved the problem, although the tripping of electricity is now confined to the external lighting circuit. The along-track lights remain switched off at all times.

4. NERC Instrument Report

4a) Campbell Scientific surface met sensors

Tipping bucket rain rates for 18th and 19th July 2009 appear to be unreliable. Although LD had cleaned out the bucket on 14th July, he hadn't noticed that the inlet was partially blocked. This caused the water to drain very slowly from the collecting funnel. He cleared the blockage on 21st July 2009. A similar problem led to rain events being missed on 6th and 7th November 2009. Although rain was measured on 5th November, the rates are much lower than those derived from the Vaisala WXT510, suggesting that the inlet was already partially blocked.

The current cold spell appears to have been more severe than the one experienced 12 months ago. Surface temperatures measured by both the Campbell Scientific and Vaisala WXT510 sensors remained predominantly around -10°C on 7th and 8th January 2010 (for a brief period during the middle of the days they rose close to 0°C). Owing to the fact that Dave Wareing (DPW) had drained the water tank before Christmas, there was no repeat of the bursting pipes seen in December 2008.

4b) Campbell Scientific surface wind sensors (Frongoch)

A loss of over 100 hours' worth of data, between 10:00 UT on 1st September 2009 and 19:34 UT on 5th September, resulted from a failure of the dial-up modem at the radar site. This is thought to have been caused by the nearby lightning strike on 1st September (see Section 3d). The modem at Frongoch was not affected.

Almost 2 months' worth of data, between 14th September and 9th November 2009, were lost after the wind vane and anemometer were damaged. This resulted from Aberystwyth University staff, who assumed that the equipment belonged to their Department, attempting to attach a wireless radio link to the 10 m tower. Although the tower was lowered most of the way without incident, it was allowed to drop for the the final metre or so. A sign has subsequently been attached to the tower, which clearly indicates that it belongs to the Facility. The sensors and data logger were returned to Campbell Scientific for repairs and recalibration. The first hour's worth of new data, i.e. 15:00 - 16:00 UT on 9th November 2009, should be ignored as repeated attempts were being made to correctly align the base of the wind vane during this period. This is a tricky procedure which involved LD securing the wind vane and rotating the base of the unit until DAH could (remotely) see readings of 0.0° being output by the data logger. The reading inevitably changed slightly when the fastening bolts were secured. The final attempt resulted in the closest alignment with a reading of 354.6° corresponded to north. At present no correction is made for this in the files made available through the BADC. It seems likely that the accuracy of the measurements made before the unit was damaged would have been comparably limited.

There is a gap in the recorded data between 22:22 UT on 1st January 2010 and 07:00 UT on 2nd January 2010. The reason for this is unknown.

4c) Vaisala WXT510 surface met and wind sensors

There is a gap in the recorded data between 09:22 and 11:13 UT on 24th July 2009. This was caused by

the acquisition PC ("augustus") being rebooted.

4d) Vaisala LD40 laser ceilometer
This instrument has recently malfunctioned twice. On the first occasion it ceased to make observations between 20:48 UT on 3rd January 2010 and 21:42 UT on the 4th. The error code indicated that this was caused by a test laser failure. Unfortunately, according to the Vaisala helpdesk, this could have been caused by a problem with any one of several internal hardware modules. Nevertheless, before any intervention could be made, the instrument mysteriously came back to life just over 24 hours after the problem began. It ceased to function again at 00:29 UT on 8th January 2010 before returning to operating order (without intervention) at 11:22 UT on the 11th. Later the same day (11th January 2010), the internally-generated message time stamp suddenly jumped from 13:23 to 03:05 UT (the date stamp also became corrupted). The clock cannot be changed without establishing a serial port connection with the instrument, for which DAH must be on site. He has already introduced a software fix for the problem in the case of the quick-look plots of the latest 24 hours' worth of data. However, the time information remains corrupted for all BADC files (and quick-look plots) starting from 11th January 2010.

ACTION ITEM 44.4.1 DAH to correct the date-time information in the cloud base altitude files and the quick-look plots stored on the BADC and to alert users to the fact when this has been done.

NEW

4e) Sky camera
A hard disk overflow on PC "claudius" led to no images being captured between 16:00 UT on 10th October 2009 and 08:23 UT on the 12th.

4f) MST Radar
The radar was powered down on 3 occasions to allow scheduled tasks to be undertaken: 08:30 - 11:32 UT on 24th July 2009, 13:25 - 16:06 UT on 3rd November 2009, and 09:58 - 12:47 UT on 17th November 2009.

A hard disk overflow on PC "claudius" (see Section 4e) caused the flow of radar data to be blocked between 16:00 UT on 10th October 2009 and 08:23 UT on the 12th. No data were lost and the backlog was processed as soon as some free space was created on the disk.

LD replaced the extractor fans on all transmitters during June and July 2009. However, the new units were poorly suited to the task and the first one failed in early September 2009. The others have subsequently failed. LD is in the process of identifying alternative units.

The radar has suffered from numerous instances of interference during the mid-winter period. Although only 1 instance occurred in July 2009 (17th), 1 in August (30th), and 2 in November, 10 instances occurred in December 2009 (on 3rd, 13th, 21st, 23rd, 25th, 27th, 28th, 29th and 31st) and 8 occurred so far in January 2010 (on 3rd, 4th, 6th, 8th, 9th and 10th). Although some of these instances were prolonged, contamination of the wind-profile data was only seen in a few cases, notably between 08:30 and 10:30 UT on 13th December 2009 and between 05:00 and 10:00 UT on the 14th. During the latter episode, DAH blocked the transmission of wind-profile data to the Met Office between 08:15 and 15:45 UT.

The radar began to suffer from an intermittent malfunction of the beam steering unit at 07:30 UT on 16th December 2009. This coincided with a prolonged period of interference, which led to DAH blocking the Met Office's data stream and to him stopping the radar at 09:57 UT. DPW power-cycled the receiver and the pre-processor unit. However, both problems persisted when the radar was restarted. DPW repeated the power-cycling routine at 15:15 UT. Although this led to the beam steering unit problem disappearing,

it recurred almost as soon as DAH had unblocked the Met Office's data stream at 18:15 UT (he quickly reinstated the block). LD was on site the following morning (17th December 2009) and quickly traced the source of the beam steering unit problem to a loose circuit board. Normal (and interference-free) operations were resumed at 10:30 UT.

The success was short-lived and an entirely separate problem, associated with the phase locking unit, interrupted observations at 11:45 UT on the following day - Friday 18th December 2009. As described in Section 3a, the source of the problem could not be easily identified and the radar was powered down until the following Monday, 21st December 2009. Normal operations were resumed at 16:00 UT.

Met Office model-comparison statistics for the last 6 months indicate that the radar-derived wind-profile data quality has been good - even during December 2009.

DAH drew attention to the fact that 30 minute averaged wind-profiles, which are generated for the Met Office, apparently give much better time-altitude coverage than single cycle data. This is largely an artifact of the the software ("gnuplot") used for creating the quick-look plots . Although the colour of each small time-altitude rectangle is typically determined by the value of just one of the 4 data points at its corners (always the same corner), a missing datum value causes white space to be shown for all 4 adjoining rectangles. For the 30 minute averaged data, a missing datum value only occurs only at those range gates for which all (typically 6) single cycle values are missing. Consequently it is highly effective at smoothing over sporadically-occurring single cycle data gaps and missing datum values occur in a smaller percentage of cases. DAH drew attention to the fact that, plotting issues aside, the quality of the 30 minute averaged wind-profile data is thought to be higher than that of the single cycle data - see Section 6b. Consequently users should consider always using some degree of time averaging.

DAH also drew attention to the fact that he will soon start to reprocess the entire MST radar observation archive using the version-3 signal processing software. Version-3 data products are currently only continuously available from June 2006 onwards. He is taking the opportunity to slightly change the netCDF file variable names in order to make them more self-explanatory and to reduce ambiguities. He will also slightly change the file names to make them consistent with the BADC's latest naming convention.

There was a general feeling that it would be useful to make time-averages of radar-derived parameters other than wind components available as standard products. This was thought to be particularly important in the case of beam-broadening corrected spectral width values, which typically show substantial variability from one cycle to the next (the most representative way of averaging such values remains to be established). There was also a feeling that dealing with netCDF files was sufficiently complicated that care should be taken with making any changes to the file or parameter names. Nevertheless, if the parameter names are changed, the file names should clearly reflect the fact that the new files are different from the earlier ones. It is important that previous versions of files/data-products are not deleted from the BADC and that the archive structure clearly separates the different versions.

ACTION ITEM 44.4.2 DAH and GAP to ensure that different versions of MST radar data products stored on the BADC are clearly distinguishable and that no old versions are deleted when the reprocessing of the entire observation archive is undertaken.

NEW

5. Guest Instrument Report

5a) FGAM instruments, including a science presentation on the Coastal Air Pollution (CAP) campaign - EGN

The boundary-layer wind-profiler (BLWP) is currently taking part in the Coastal Air Pollution (CAP)

campaign at Weyborne (Norfolk). The main objectives of this campaign are to asses the impact of local meteorology on coastal air quality and to study the evolution of the coastal boundary layer structure. Atmospheric measurements have been made continuously at the Weyborne site since 1993. It is known that the air quality is not always consistent with predictions based on ECMWF trajectories. Consequently local meteorology is thought to play a role. The campaign has involved a number of aircraft overflights of the site at low altitude.

The antenna switch of the BLWP was replaced in November 2009 after it developed a a fault. It was not properly disconnecting from one (off-vertical) antenna panel before connecting to the next. This led to two atmospheric signal components, with different Doppler velocities, being visible in single spectra. Ground clutter has proved to be something of a problem at the Weyborne site as there is no clutter screen available there. The BLWP also suffered from interference caused by a nearby sodar/RASS instrument.

The software on the BLWP's data acquisition PC (PCA) has been updated. This makes it much easier to update site specific information when moving the instrument from one campaign to another. The new software also has an improved method for avoiding range aliasing. The inter pulse period for the low-altitude mode is automatically increased if strong signals are detected at the higher altitudes in the high-altitude mode. The software has also been updated on the data processing PC (PCT). This is now better at retaining data (which were previously rejected) under conditions of intermittent precipitation. Isolated wind measurements are now subject to additional quality control checks rather than simply being accepted. Turbulence parameters can now be be displayed by the processing software.

The FGAM BLWP will be moved to Chilbolton in the near future in order to participate in the MO's Future Upper-Air Network Development (FUND) project. The MO's 5-panel Degreanne BLWP is already in place there. It has its own dedicated clutter screen.

5b) University of Manchester static instruments
The water vapour lidar is now automated so that it can be controlled over the internet from Manchester. DPW is in the process of similarly automating the ozone lidar. The E-light lidar has developed a leak and requires repairs to restore it to working order. The water froze in its pipes over the Christmas 2009 period.

5c) Met Office GPS receiver
A failure of an internal component has meant that the receiver was not functioning for some time. It was returned to the manufacturer for repairs before Jonathan Jones brought it back to the radar site on 15th January 2010. However, the lack of an appropriate power adaptor meant that he could not get it working straight away.

6. Science and technical presentations

6a) The Temperature, Humidity and Water (THAW) campaign - DJH
This project aims to understand the physics behind the scattering of MST radar signals, including those returned from non-turbulent parts of the atmosphere. It is linked to the MO's FUND project. As described in Section 3b, it was conducted between 23rd November and 4th December 2009. By good fortune everything worked out perfectly to coincide with the FAAM aircraft overflight on 30th November. This date was chosen since a tropopause fold passed over the site. The clouds cleared towards the end of the afternoon, which allowed the Raman lidar to be operated using 3 channels. The aircraft was able to make in situ measurements as it performed a slow (150 m per minute) nominally-spiral descent. Radiosondes were launched from the site every couple of hours. Measurements of temperature and humidity will be used to model the expected radar return power.

KL pointed out that MO high-resolution radiosonde data from Castor Bay (Northern Ireland) might be

of use for the primary campaign day (the files are available through the BADC). The northerly winds would have caused the radiosonde ground tracks to pass close to the radar site. He also drew attention to the fact that the MO can launch additional radiosondes to support campaigns, albeit under a commercial agreement.

6b) Opportunities for increasing the exploitation of MST radar data products - DAH
There are many aspects of the MST radar dataset which appear to offer useful information but which have yet to be exploited. DAH proposed that the following three questions were of particular importance. What is the optimal level of time averaging of wind-profile data? What information is contained in the high time-resolution (i.e. 47 s interval) vertical beam data? What information is contained in the radar scatter zenith angle dependence (which is commonly referred to as aspect sensitivity)?

DAH and Catherine Gaffard have already begun to consider the first question. It appears that the variations between single cycle wind-profiles are dominated by random measurement errors. The use of 30 minute averaging (as in the case of the data supplied to the Met Office) clearly reduces the significance of these errors. However, it remains to be established whether or not 30 minutes is the most appropriate averaging period. CFL has already started to consider the second question by calculating power spectra of vertical velocity variations. It is known that, under certain circumstances, these can show a local maximum at around the Brunt-Väisälä period. CFL suspects that such spectra could be more useful for studying gravity waves than turbulence. With respect to the third question, the often highly-structured patterns seen in the values of the radar scatter zenith angle dependence clearly contain information regarding the state of the atmosphere. However, it is far from clear what these are telling us beyond that it is something to do with how well mixed the refractive index structure is.

The significance of the shape of signal components in the spectral domain was also discussed. It was noted that the signal components could often be distinctly non-Gaussian, particularly within regions which are thought to be turbulent. Perhaps they could be incoherently integrated over periods of the order of half an hour in order to come up with a more representative value of spectral width? It was also noted that the time-altitude coverage of useful radar observations could probably be improved simply by improving the way in which quality control information is combined. At present the mechanism is somewhat conservative as it discards many data points which are apparently reliable (on the other hand, it is quite good at avoiding contamination from clearly erroneous data points).

7. Any Other Business

GAP reported that historical radiosonde data from South Uist are now available through the BADC. DJH asked where, on the BADC, radiosonde data from Capel Dewi should be placed. It was agreed that this should be under the UFAM data area.

Attention was drawn to the fact that the NCAS conference would be held 5th - 7th July 2010 in Manchester. The 15th International Symposium for the Advancement of Boundary Layer Remote Sensing (ISARS) will be held in Paris 28th - 30th June 2010.

The next Experimenters' Meeting is provisionally scheduled for Thursday 24th June 2010 at the Cosener's House.